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Review

Can pre-operative computed tomography predict the need for a thoracic approach for removal of retrosternal goitre?☆

Ali Qureishi, George Garas, Neil Tolley, Fausto Palazzo, Thanos Athanasiou, Emmanouil Zacharakis*

Department of Surgery and Cancer, St. Mary's Hospital, Imperial College London, United Kingdom

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ABSTRACT

A best evidence topic was written according to a structured protocol. The question addressed was whether in patients with retrosternal goitre the need for a thoracic approach can be predicted using pre-operative CT. A total of 381 papers were identified using the reported search protocol of which 7 represented the best evidence to answer the clinical question. The authors, journal, date, country of publication, patient group studied, study type, relevant outcomes and results are tabulated. The evidence on this subject is poor, none of the studies were randomised, only one used controls (historical) and all studies were retrospective. Despite these limitations, CT represents the gold-standard imaging modality in the pre-operative evaluation of patients with retrosternal goitre. CT is essential to define the extent and position of a retrosternal goitre. The literature suggests that CT is the single most valuable pre-operative investigation predicting whether a sternotomy or lateral thoracotomy will be necessary for removal of the retrosternal goitre. Although pre-operative CT does not have the precision to predict whether a thoracic approach is required in all cases, the presence of certain radiological features such as extension of the goitre below the aortic arch or into the posterior mediastinum, a dumbbell shape and a thoracic component that is wider than the thoracic inlet are all associated with the need for a thoracic approach. In some cases a pre-operative CT will not only determine that a thoracic approach is mandatory but it will also guide the surgeon upon the type of thoracic approach.

1. Introduction

A best evidence topic was constructed according to a structured protocol. This is fully described in a previous publication in the *International Journal of Surgery*.[1]

2. Clinical scenario

A colleague is due to perform a total thyroidectomy on a patient with a retrosternal goitre. Pre-operative Computed Tomography (CT) has demonstrated that >50% of the goitre extends below the thoracic inlet. He asks for your opinion on whether a cervical approach would be sufficient or whether a thoracic approach may be indicated based on the CT findings. You resolve to assess the literature yourself.

3. Three-part question

Can pre-operative computed tomography predict the need for a thoracic approach for removal of retrosternal goitre?

4. Search strategy

Medline search 1948–2012 using the PubMed interface for the terms: ("Substernal"[All Fields] OR "Retrosternal"[All Fields] OR "Intrathoracic"[All Fields] OR "Sternotomy"[All Fields]) AND ("Thyroid"[All Fields] OR "Goitre"[All Fields]).

In addition, the reference lists of the relevant papers were searched. The search was current as of 1st January 2013.

5. Search outcome

381 papers were found using the reported search. Two authors (A.Q. and G.G.) independently assessed the titles and abstracts of the identified articles to determine potential relevance. Any disagreement was resolved by discussion or with the opinion of the senior author (E.Z.). After reviewing the abstracts, 289 papers were selected to be fully appraised in view of relevance and methods

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* Corresponding author. Department of Biosurgery and Surgical Technology, Imperial College London, St Mary's Hospital, London W2 1NY, United Kingdom. Tel.: +44 02078866666; fax: +44 02078867950.
E-mail address: e.zacharakis@imperial.ac.uk (E. Zacharakis).

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used. From these, 119 were irrelevant, 108 did not define the term "retrosternal goitre" or defined it differently to ">50% of its mass below the thoracic inlet", 36 were review articles, 17 were not in English and 2 were studies involving paediatric patients. Inclusion criteria included studies of any size, prospective or retrospective in design that evaluated the type of surgical approach required for removal of retrosternal goitre. All patients included had to be adults and had to have a retrosternal goitre removed which was defined as ">50% of its mass extending below the thoracic inlet". Exclusion criteria included studies where the term "retrosternal goitre" was not defined or defined differently and studies including paediatric patients. Review articles and articles not published in the English language were also excluded. Based on design, number of patients and origin (high volume/specialised centres) 7 papers were chosen as representing the best evidence to answer the clinical question.

6. Results

The results of the seven papers (one retrospective case-controlled series and six retrospective case series) are summarised in Table 1.

7. Discussion

Identification of patients with retrosternal goitre (RSG) requiring a thoracic approach is important as it allows for pre-operative preparation and planning. Surgery in these patients may require the involvement of thoracic surgeons, access to specialist equipment and a post-operative stay in a high dependency unit. Thorough pre-planning is of particular importance as many hospitals do not possess the necessary resources and expertise on site. In such cases the required personnel and equipment will have to be outsourced from another institution at short notice leading to suboptimal patient care and a risk to the patient. Equally being able to predict when a thoracic approach is not mandated is also important as it will obviate the need to transfer a thoracic team to another hospital on a standby basis with the reality of them only occasionally being required.

Identifying the need for a thoracic approach also allows for a more appropriate informed consent of the patient following provision of better information prior to surgery. Pre-operative CT helps with the informed consent process by providing a better idea of what is to be expected. Informed of the probable need for a sternotomy or lateral thoracotomy some patients may be less willing to opt for surgery, especially in borderline cases where the decision between a conservative and surgical approach is not clear cut.[2]

The definitions of RSG vary but the commonest definition is that of a thyroid gland with >50% of its mass located below the thoracic inlet; 10.6% of these patients and 45.1% of patients with the thyroid gland reaching the aortic arch are likely to require a thoracic surgical approach (manubriotomy, sternotomy or lateral thoracotomy).[3] To date, there is no randomised controlled trial (RCT) to assess the value of pre-operative CT scanning in predicting the need for a thoracic approach in patients with RSG. However, a number of studies have identified important individual risk factors.

Raffaelli et al.[4] retrospectively evaluated patients treated surgically for RSG and identified case-specific factors resulting in the need for a thoracic approach. RSG was defined as an enlarged thyroid with >50% of the gland or any nodule located in the mediastinum. In this study of 355 patients with RSG, the largest series in the literature, only 2 required a thoracic approach. In both cases this was to improve access and facilitate haemostasis due to the increased risk of bleeding in patients with mediastinal recurrence of thyroid cancer with innominate vein invasion and RSG with mediastinal blood supply respectively. The series identified no significant difference in complications for patients treated surgically with cervical goitre and RSG ($p = 0.06$). Limitations included the retrospective nature of the study, lack of randomisation and the failure to perform CT imaging in all cases resulting in 79 of the 355 patients with RSG being diagnosed intraoperatively. Furthermore it was unclear if any patients with primary intrathoracic goitre or mediastinal malignant spread were operated on successfully through a cervical incision alone.

Cohen[5] conducted a retrospective review of 113 patients with RSG and compared the patients treated with a cervical approach to those who underwent a thoracic approach. RSG was defined as a thyroid (or any thyroid nodule) with >50% located within the mediastinum. The study compared symptoms, histology, complications and identified risk factors for sternotomy. Five patients required a sternotomy. Differences between the two groups were identified with regards to the incidence of malignancy (11.1% cervical vs. 20% thoracic approach), extension of the goitre into the posterior mediastinum (0% vs. 20%), below the aortic arch (2.8% vs. 60%) and with regards to ectopic thyroid tissue (0.9% vs. 60%). The authors concluded that RSG could be removed safely through a cervical approach; however extension into the posterior mediastinum, adherence to mediastinal structures, presence of an ectopic goitre and extension below the aortic arch increased the risk of needing to convert to a sternotomy. Each of these features could have been identified on pre-operative CT. The authors concluded that sternotomy was safe and may have been an underutilised approach to facilitate access in challenging cases. Limitations of the study include its retrospective nature, absence of control group and randomisation as well as the presence of small crossover as one patient who did not undergo a sternotomy was included in the sternotomy group. This was a retrospective decision made after it was noted that the patient had incomplete excision.

Cichon et al.[6] presented a retrospective series of 88 patients with RSG comparing the operative approach, risk factors for sternotomy and complications. Twenty seven patients required a thoracic approach. The authors defined RSG as a thyroid gland with >50% of its mass extending into the thorax reaching at least the level of the aortic arch. This meant that their patient population would have been considered at a higher risk of sternotomy. In this high risk population it was found that statistically significant risk factors for sternotomy were recurrent goitre ($p = 0.01$), location in the posterior mediastinum ($p = 0.037$), aberrant adenoma ($p = 0.006$) and mediastinal blood supply ($p = 0.002$). The overall post-operative morbidity rating was 26.7% compared to 29.63% for patients undergoing sternotomy. The quality of this series was limited by its retrospective nature, lack of randomisation and absence of control group.

Erbil et al.[7] reported 170 cases of RSG, of which 12 required a thoracic approach. The study included patients with RSG defined as having at least 50% of the thyroid gland located inferior to the thoracic inlet. Deep intrathoracic extension and dense fibrotic adhesions were indicators for a thoracic approach. Pre-operative CT imaging of the mediastinum was useful in identifying these features. Limitations of this study included its retrospective nature, lack of randomisation, absence of control group, variability in pre-operative imaging and lack of detailed information for each case requiring a sternotomy.

Cui et al.[8] reported a retrospective series of 64 patients with RSG undergoing a total of 70 operations. RSG was defined as a thyroid gland with >50% of the goitre below the suprasternal notch. Fifteen cases required a thoracic approach. The authors noted 'giant RSG' (not defined, $n = 5$), recurrent goitre ($n = 4$), malignancy (especially undifferentiated carcinoma, $n = 4$), and intrathoracic ectopic goitre ($n = 3$) as factors necessitating a thoracic approach. Pre-operative

Table 1
Best evidence papers.

Author, date and country	Patient group	Study type and level of evidence	Outcomes	Key results	Comments
Raffaelli et al. 2010,[4] Italy	Patients with RSG (defined as >50% of the gland or any thyroid nodule located in the mediastinum) ($n = 355$) were compared to patients with CG ($n = 355$) matched for age and gender. All patients had surgery from 2004 to 2008 in one tertiary referral centre. RSG group: 338 had TT, 4 had TL and 13 had CT, mean age 57.3 years, gender: 102 male and 253 female. Final histology: 71 malignant and 284 benign disease.	Level IV retrospective case-controlled series	Surgical approach required for removal of RSG (CA vs. ECA) Other outcomes (comparison of CG vs. RSG for pre-operative diagnosis and rate of malignancy, comparison of CA vs. ECA for operative time, LOS and post-operative complications)	RSG group: CA ($n = 353$) ECA ($n = 2$) Factors necessitating thoracic approach: Mediastinal recurrence of thyroid cancer with suspicion of innominate vein invasion. Primary retrosternal goitre with mediastinal blood supply.	This retrospective case-controlled series demonstrated that the majority of RSG could be removed using a cervical incision except when there was invasion of mediastinal structures by carcinoma or primary intrathoracic goitre due to a higher risk of bleeding. The series identified no significant difference in complications for CG and RSG. The quality of this series is diminished by its retrospective nature, lack of randomisation and failure to perform CT imaging in all cases meaning 79 of 355 patients with RSG were diagnosed intraoperatively. Furthermore it is unclear if any patients with primary intrathoracic goitre or mediastinal malignant spread were operated on successfully through a cervical incision alone.
Cohen 2009,[5] USA	A case series ($n = 113$) of patients with RSG (defined as >50% of any thyroid nodule located in the mediastinum) is presented. Operated by a single surgeon between January 1998 and December 2007. 51 had TL, 55 TT, 6 CT, 1 ST, mean age 56.9, gender: 29 male, 84 females. Final histology: 13 malignant, 100 benign disease.	Level IV retrospective case series	Surgical approach required for removal of RSG (CA vs. ECA) Other outcomes (comparison of CG vs. RSG for pre-operative symptoms and rate of malignancy, comparison of CA vs. ECA for post-operative complications)	CA ($n = 108$), ECA (sternotomy) ($n = 5$) Factors necessitating thoracic approach: Extension into posterior mediastinum 1/5 (20%), Extension below aortic arch 3/5 (60%), Ectopic nodule 3/5 (60%), Pre-operative CT indicating malignancy adherent to mediastinal structures 1/5 (20%).	This retrospective case series demonstrated that the majority of RSG could be removed through a cervical incision except when there was extension into the posterior mediastinum, below the aortic arch, malignancy adherent to mediastinal structures, or the presence of an ectopic mediastinal goitre, features that could be seen using pre-operative computed tomography. The study showed median sternotomy to have a low complication rate and suggested it as an underutilised technique for managing patients with RSG. The quality of this series was diminished by its retrospective nature, lack of control group and randomisation and the fact that 1 patient who did not receive sternotomy was included in the sternotomy group. This was a retrospective decision made after it was noted that the patient had had incomplete excision.
Cichon et al. 2008,[6] Poland	Case series ($n = 88$) of patients undergoing surgery for RSG (defined as >50% of goitre mass within chest cavity reaching at least as far as the aortic arch) between 1984 and 2004 at a single University Hospital. 33 had TT, 46 ST, 4 TL, 4 CT for mediastinal component, 1 mediastinal component	Level IV retrospective case series	Surgical approach required for removal of RSG (CA vs. ECA) Other outcomes (comparison of CG vs. RSG for rate of malignancy,	CA ($n = 61$), ECA (sternotomy) ($n = 27$) Factors necessitating sternotomy: Recurrent goitre 8/27 ($p = 0.01$),	This retrospective case series showed that statistically significant risk factors for sternotomy were: recurrent goitre, primary mediastinal goitre, posterior mediastinal location and the presence of an aberrant mediastinal adenoma. The quality of this series was diminished by its retrospective nature

(*continued on next page*)

Table 1 (*continued*)

Author, date and country	Patient group	Study type and level of evidence	Outcomes	Key results	Comments
	excision alone, mean age 61, gender: 24 males, 64 female. Final histology: 2 malignant, 86 benign disease.		comparison of CA vs. ECA for post-operative complications)	location in posterior mediastinum 15/27 ($p = 0.037$), aberrant adenoma 7/27 ($p = 0.006$), mediastinal blood supply 6/27 ($p = 0.002$)	and a lack of randomisation and control group.
Erbil et al. 2004,[7] Turkey	Case series ($n = 170$) of patients surgically treated for RSG (defined as at least 50% of thyroid gland located inferior to thoracic inlet) between 1990 and 2003 in a single surgical unit. 40 had TT, 68 bilateral NT, 20 TL, 42 bilateral ST, median age 46, gender: 37 male, 133 female. Final histology: 22 malignant, 148 benign disease.	Level IV retrospective case series	Surgical approach required for removal of RSG (CA vs. ECA) Other outcomes (overall post-operative complications)	CA ($n = 158$) ECA (partial median sternotomy) ($n = 12$) Factors necessitating thoracic approach: Deep intrathoracic extension, enlarged glands in posterior mediastinum and dense fibrotic adhesions from previous surgery.	This retrospective case series demonstrated that the majority of RSG could be removed through a cervical excision except when there were mediastinal adhesions or deep mediastinal location. The quality of this series was diminished by its retrospective nature, lack of randomisation, control group, variability in pre-operative imaging and lack of detailed information for each case requiring sternotomy.
Cui et al. 2002,[8] China	Case series ($n = 64$) of patients with RSG (defined as >50% of goitre below suprasternal notch) managed surgically from 1961 to 1999 in a single University Hospital. Mean age 52, Gender: 19 male, 45 female, final histology: 10 malignant and 54 benign disease.	Level IV retrospective case series	Surgical approach required for removal of RSG (CA vs. ECA) Other outcomes (overall post-operative complications)	64 patients underwent total of 70 operations. CA ($n = 55$) ECA ($n = 15$) (7 cervical incision and sternotomy, 3 cervical incision and thoracotomy, 5 thoracotomy). Factors necessitating thoracic approach: Giant RSG ($n = 5$/15), recurrent goitre ($n = 4$/15), malignancy (especially undifferentiated carcinoma) ($n = 4$/15), intrathoracic ectopic tissue ($n = 3$/15).	This retrospective case series showed that a cervical approach is usually sufficient; however malignancy, recurrence, ectopic intrathoracic thyroid tissue and size can predict the need for an extra-cervical (thoracic) approach. Pre-operative CT allows the surgeon to locate multiple goitres pre-operatively and plan surgery appropriately. The quality of this series was diminished by its retrospective nature, lack of randomisation and control group and failure to define 'giant RSG'.
Arici et al. 2001,[9] Turkey	Case series ($n = 52$) of patients with RSG (defined as >50% of mass resided substernal or in mediastinum) managed surgically between January 1995 and June 2001 in a single University Hospital. 7 had TT (2 also had unilateral modified neck dissection), 18 ST, 21 bilateral ST, 6 TL, median age 52, gender: 27 male, 25 female, final	Level IV retrospective case series	Surgical approach required for removal of RSG (CA vs. ECA) Other outcomes (presenting symptoms, overall post-operative complications)	CA ($n = 50$) ECA (partial median sternotomy) ($n = 2$) Factors necessitating thoracic approach: 'Very large retrosternal mass'	This retrospective case series identified that the majority of RSG can be removed via a cervical incision, except when a 'very large' RSG is present. A CT scan can show the relationship of the goitre to the trachea, oesophagus, great vessels and depth of extension in the chest. This test is probably the most useful in evaluating RSG.

	histology: 6 malignant, 46 benign disease.				The quality of this series was diminished by its retrospective nature, lack of randomisation and control group, failure to define 'very large retrosternal mass' and the fact that only 38% of patients had pre-operative CT scan.
Shai et al. 2000,[10] Taiwan	Case series ($n = 56$) of patients with RSG (defined as >50% mass of gland below thoracic inlet) were treated between August 1983 and September 1999 in a single surgical unit. 30 had TL and isthmusectomy, 7 bilateral ST, 9 DP, 9 unspecified procedures, mean age 62.3, gender: 25 males, 31 females. Of those undergoing surgery 6 had cancer, 49 benign disease.	Level IV retrospective case series	Surgical approach required for removal of RSG (CA vs. ECA) Other outcomes (comparison of CA vs. ECA for operative time and post-operative complications)	CA ($n = 46$) ECA ($n = 9$) (1 thoracotomy, 7 cervical incision and sternotomy, 1 cervical incision and thoracotomy) Factors necessitating thoracic approach: 'giant post-mediastinal goitre, superior vena cava syndrome or acute airway obstruction'.	This retrospective case series indicated that a cervical approach is appropriate in all patients except when patients have a 'giant' recurrent, posterior mediastinal goitre or if they present with an airway emergency or superior vena cava syndrome. In these patients a cervical approach risks uncontrollable haemorrhage, incomplete removal and RLN paresis. Pre-operative CT is useful as it delineates degenerative changes, necrosis, fibrosis and calcification, and in contrast to iodine scintigraphy scanning can identify poorly differentiated margins and invasion of adjacent structures, thus raising the suspicion of malignancy. The quality of this series was diminished by its retrospective nature, lack of randomisation and control group and failure to define 'giant goitre'.

RSG = retrosternal goitre (>50% extension below thoracic inlet); CG = cervical goitre; TT = total thyroidectomy; ST = subtotal thyroidectomy; NT = near-total thyroidectomy, TL = thyroid lobectomy; CT = completion thyroidectomy; DP = Dunhill's procedure (unilateral total thyroid lobectomy and contralateral sub-total thyroid lobectomy); RLN = recurrent laryngeal nerve, CA = cervical approach, ECA = extra-cervical (thoracic) approach, LOS = length of stay.

CT imaging in these cases allowed surgeons to delineate the extension of multiple goitres and plan surgery appropriately. The quality of this series was diminished by its retrospective nature, lack of randomisation, absence of control group and failure to define 'giant RSG'.

Arici et al.[9] reported a series of 52 patients with RSG treated surgically. Two patients required a thoracic incision. RSG was defined as a thyroid gland with >50% of its mass residing substernally or in the mediastinum. The thoracic approach was reserved for 'very large retrosternal masses' (not defined). The authors highlighted the importance of pre-operative CT imaging in determining the relationship of the goitre to the trachea, oesophagus, great vessels and the level of extension within the thorax. CT was felt to be the most useful tool for pre-operative evaluation of RSG. Limitations of this study included its retrospective nature, lack of randomisation, absence of control group, failure to define 'very large retrosternal mass' and the fact that only 38% of included patients actually had pre-operative CT scans.

Shai et al.[10] conducted a review of 56 patients with RSG operated on using a cervical and thoracic approach. RSG was defined as a thyroid gland with >50% of its mass below the thoracic inlet. Twenty three of 56 patients had a thyroid gland which reached the aortic arch or carina, however this was not highlighted as a risk factor. In total, in 9 patients was a thoracic approach necessitated. These were due to 'giant post-mediastinal goitre' (not defined), superior vena cava syndrome and acute airway obstruction. It was felt that a cervical approach alone would risk uncontrollable haemorrhage, incomplete removal and nerve damage. Pre-operative CT was useful in delineating degenerative changes, necrosis, fibrosis and calcification. Moreover, in contrast to iodine scintigraphy scans, CT allowed identification of poorly differentiated margins and the invasion of adjacent structures, thus raising the suspicion of malignancy. The quality of this series was reduced by its retrospective nature, lack of randomisation, absence of control group and failure to define 'giant goitre'.

From the above, it becomes evident that the vast majority of RSGs can be extricated from a cervical approach and that a pre-operative CT is essential to define the extent and position of a RSG. A pre-operative CT does not have the precision to predict whether a thoracic approach is required in all cases, however in some it will not only determine that a thoracic approach is mandatory but it will also allow a decision to be made upon the type of thoracic approach. In posterior mediastinal goitres or those arising from ectopic thyroid tissue which typically are right sided, a lateral thoracotomy and not sternotomy is required. A sternotomy will not facilitate surgery for posterior mediastinal goitres.

8. Clinical bottom line

Based on the existing evidence, and despite its limitations (only retrospective studies exist on the subject), CT represents the gold-standard imaging modality in the pre-operative evaluation of patients with retrosternal goitre. The literature suggests that CT is the single most valuable pre-operative investigation predicting whether a sternotomy or lateral thoracotomy will be necessary for removal of the retrosternal goitre.

A pre-operative CT allows the quantification of the retrosternal component of the goitre and perhaps more importantly the shape and position of the thoracic component. Although pre-operative CT does not have the precision to predict whether a thoracic approach is required in all cases, the presence of certain radiological features such as extension of the goitre below the aortic arch or into the posterior mediastinum, a dumbbell shape and a thoracic component that is wider than the thoracic inlet are all associated with the need for a thoracic approach. In some cases a pre-operative CT will not only determine that a thoracic approach is mandatory but it will also guide the surgeon upon the type of thoracic approach.

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Author disclosure form

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Author contribution

Ali Qureishi: conception of idea, data collection, co-wrote manuscript with GG.

George Garas: conception of idea, data collection, co-wrote manuscript with AQ.

Neil Tolley: reviewed and corrected manuscript.

Fausto Palazzo: reviewed and corrected manuscript.

Thanos Athanasiou: reviewed and corrected manuscript.

Emmanouil Zacharakis: conception of idea, reviewed and corrected manuscript.

Conflicts of interest

There are no conflicts of interest.

References

1. Khan OA, Dunning J, Parvaiz AC, Agha R, Rosin D, Mackway-Jones K. Towards evidence-based medicine in surgical practice: best BETs. *Int J Surg* 2011;**9**(8):585–8.
2. Hardy RG, Bliss RD, Lennard TW, Balasubramanian SP, Harrison BJ. Management of retrosternal goitres. *Ann R Coll Surg Engl* 2009;**91**(1):8–11.
3. Huins CT, Georgalas C, Mehrzad H, Tolley NS. A new classification system for retrosternal goitre based on a systematic review of its complications and management. *Int J Surg* 2008;**6**(1):71–6.
4. Raffaelli M, De Crea C, Ronti S, Bellantone R, Lombardi CP. Substernal goiters: Incidence, surgical approach, and complications in a tertiary care referral center. *Head Neck* 2011;**33**(10):1420–5.
5. Cohen JP. Substernal goiters and sternotomy. *Laryngoscope* 2009;**119**(4):683–8.
6. Cichon S, Anielski R, Konturek A, Baczynski M, Cichon W, Orlicki P. Surgical management of mediastinal goiter: risk factors for sternotomy. *Langenbecks Arch Surg* 2008;**393**(5):751–7.
7. Erbil Y, Bozbora A, Barbaros U, Ozarmagan S, Azezli A, Molvalilar S. Surgical management of substernal goiters: clinical experience of 170 cases. *Surg Today* 2004;**34**(9):732–6.
8. Cui Y, Zhang Z, Li S, Li L, Zhang H, Li Z. Diagnosis and surgical management for retrosternal thyroid mass. *Chin Med Sci J* 2002;**17**(3):173–7.
9. Arici C, Dertsiz L, Altunbas H, Demircan A, Emek K. Operative management of substernal goiter: analysis of 52 patients. *Int Surg* 2001;**86**(4):220–4.
10. Shai SE, Chen CY, Hsu CP, Hsia JY, Yang SS, Chuang CY, et al. Surgical management of substernal goiter. *J Formos Med Assoc* 2000;**99**(11):827–32.